Salinity

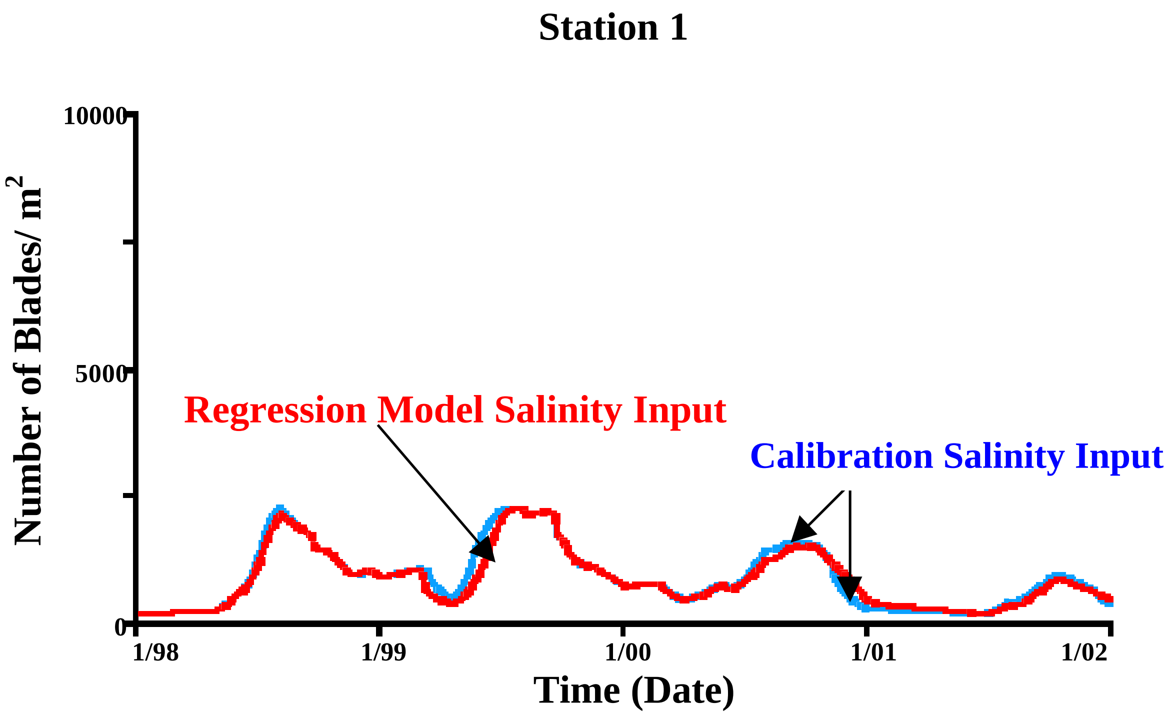
Use of salinity data interpolated from the field data (input to the calibration runs) or salinity input from the regression model, (**Appendix F**) does not produce a significant impact on *V. americana* densities at either Station 1 or Station 2 during the four-year of calibration period (**Figures H-8 and H- 9**).

Light

The use of an averaged annual secci disk depth input file produced differences compared to the calibrated model, which uses field measurements at both Station 1 and 2. (**Figure H-10**). The blade density at both stations 1 and 2 is overestimated in 2000 and 2001. This is due to underestimation of true water transparency using the averaged annual input file and illustrates the importance of light limitation in these two years. Additionally at Station 2, the average annual input file results in an underestimation of blade density in 1998 due to increased water transparency relative to the four-year average (**Figure H-11**).

The averaged annual data files resulted in secci disk depths ranging from 0.9 m to 1.3 m at Station 1 during the course of a year. The field data for the four-year calibration period shows a greater degree in variability in measurements ranging from 0.5 to 1.75m (**Figure H-11**). At Station 2, field measurements fall below 0.3m (data not shown). Thus the averaged data files do not account for the variability and extremes events such as phytoplankton blooms or highly colored water from basin discharge nor do they represent years that have very high water transparency such as that of 1998. It is these extreme values that may have the greatest impacts on *V. americana* growth.

The parameter I_k derived from P/I relationships is used directly in the determination of the light effect. The sensitivity of blade density to raising or lowering I_k within ranges reported in the literature (Harley and Findlay, 1994) is shown in **Figure H-12.** At both stations variations in I_k simply raised or lowered the peak density values. The model currently assumes this value to be constant over all environmental conditions. As discussed previously, research has indicated that P/I relationships (and thus I_k) are dynamic and can potentially change with water temperature, salinity, and prior exposure. Due to lack of quantifiable information available at the present time, this value remains constant in the current model. Analysis of recent experimental work (Hunt et



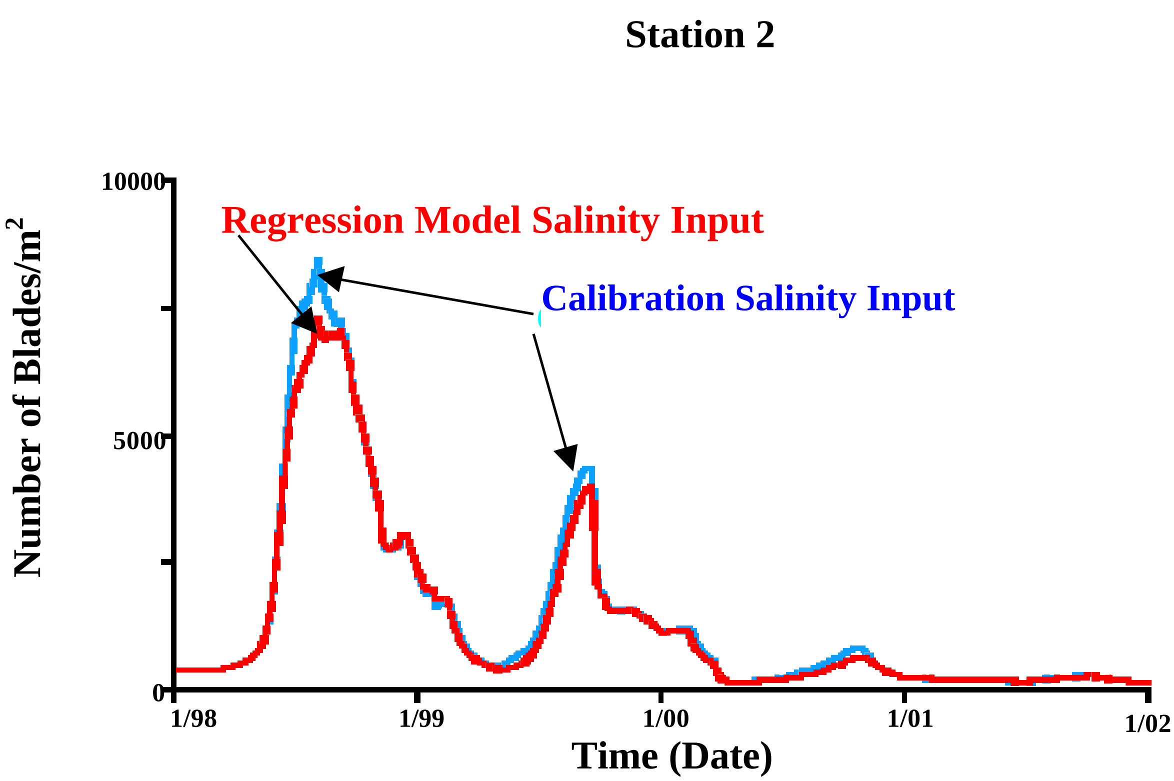


Figure H-8: Results of modeled *V. americana* Blade Densities Using Different Salinity Input

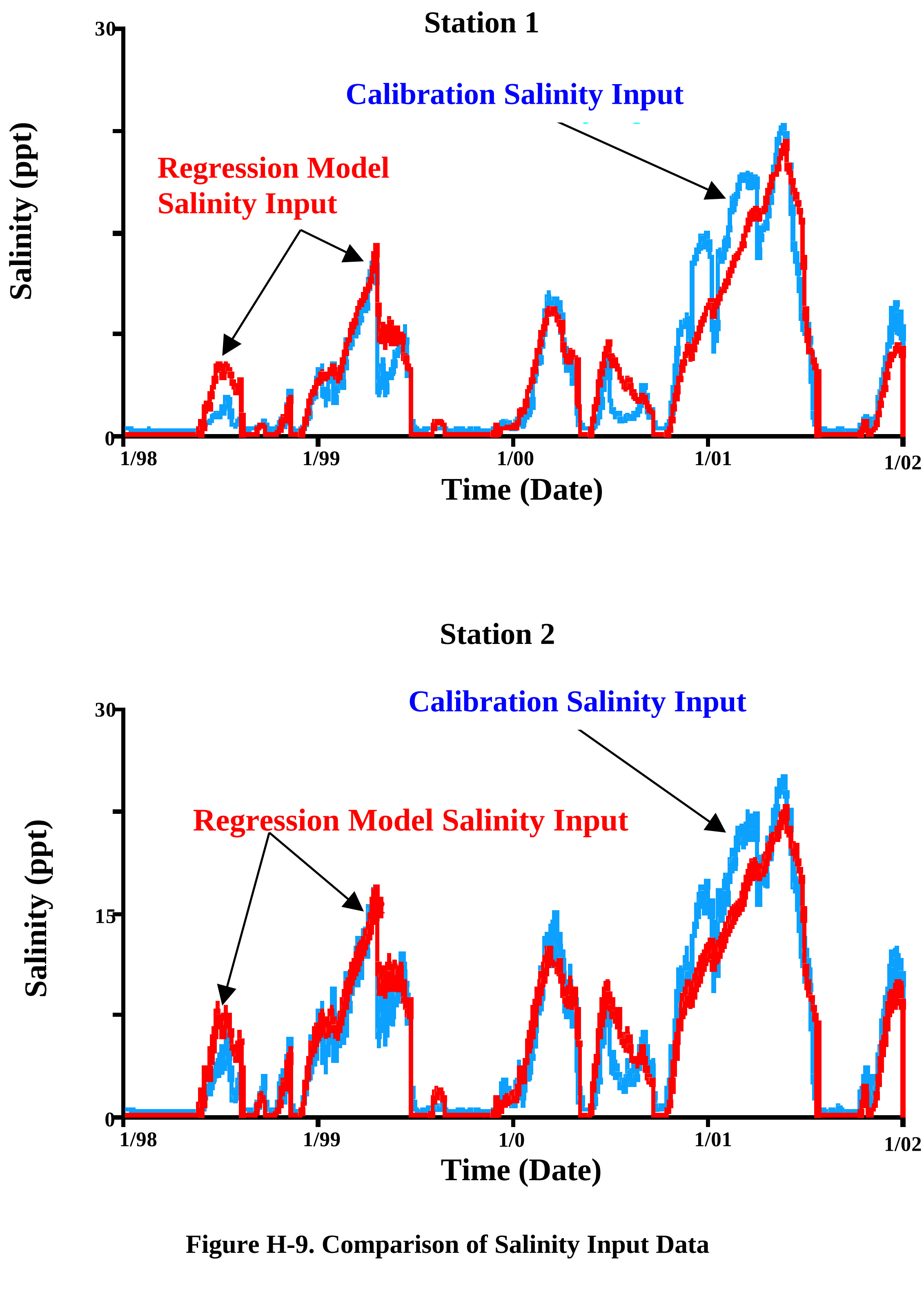


Figure H-9. Comparison of Salinity Input Data

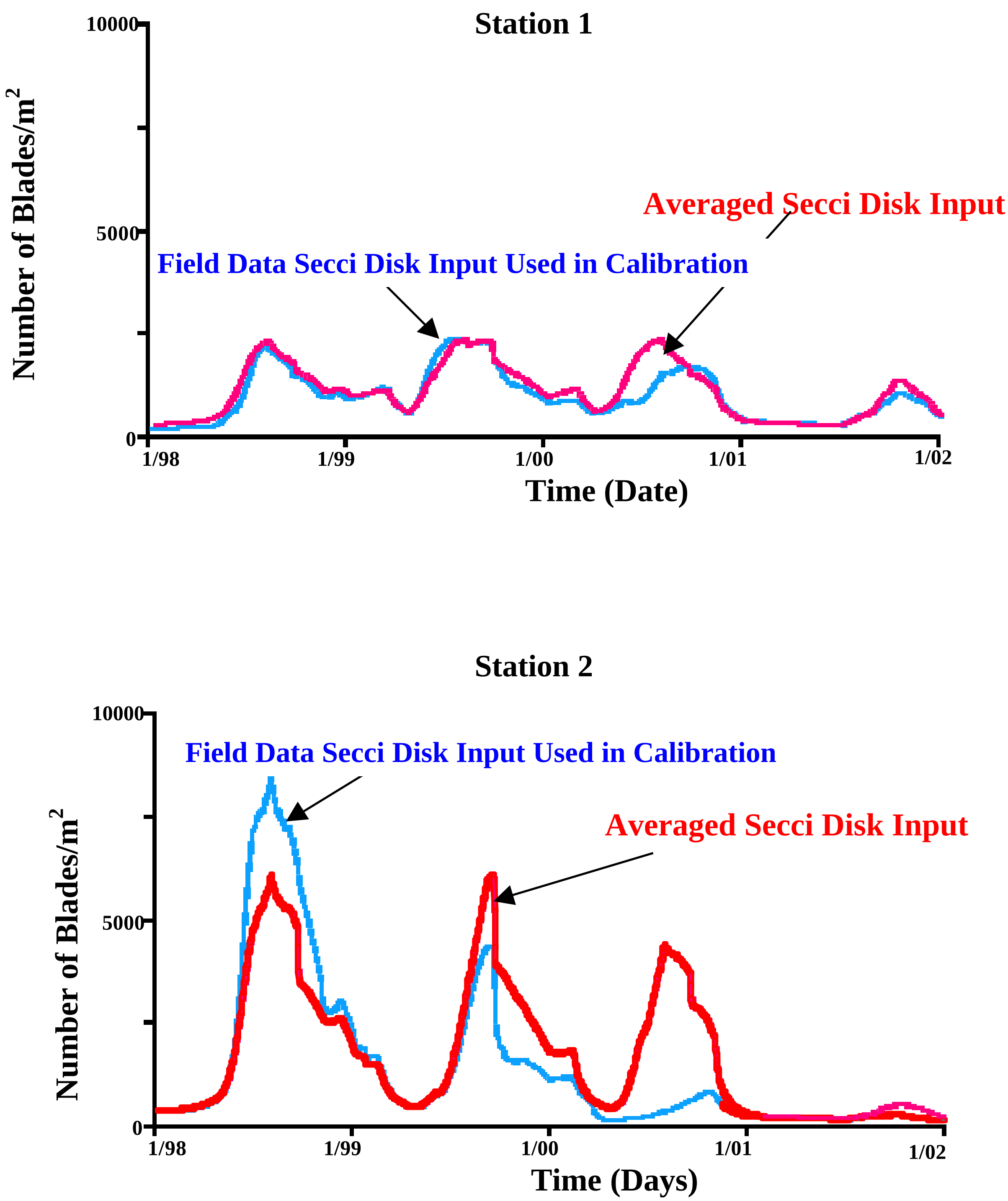
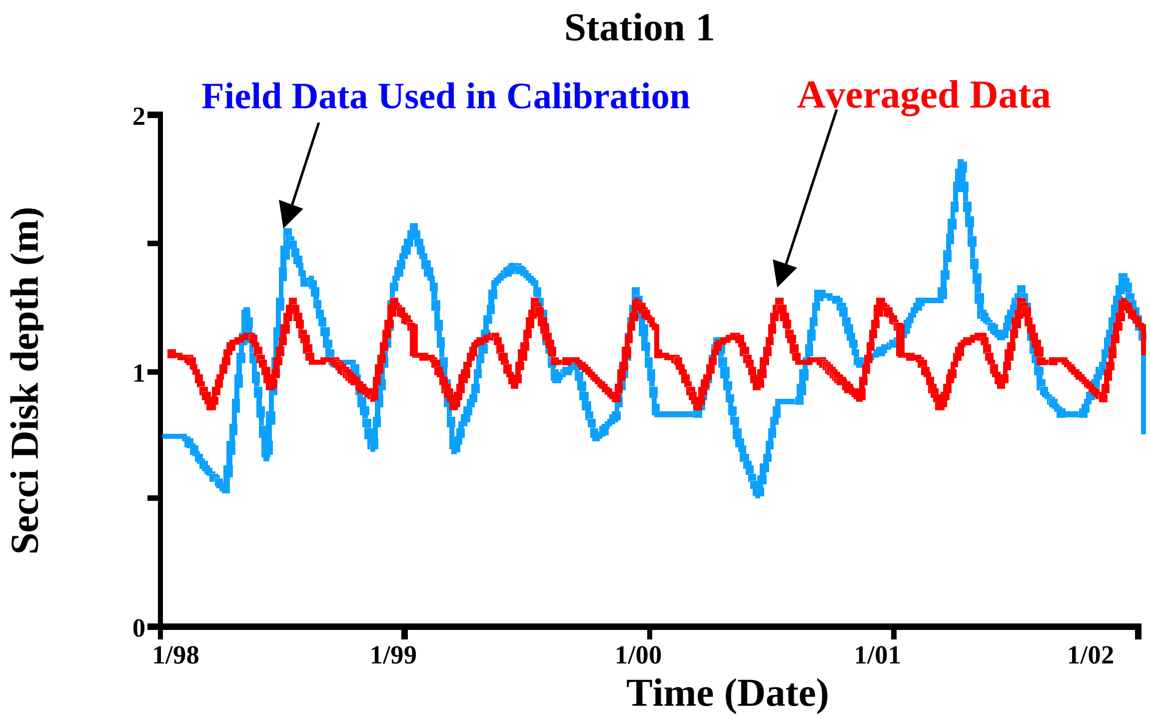


Figure H-10: Results of modeled *V. americana* Blade Densities Using Different Water Transparency Input.



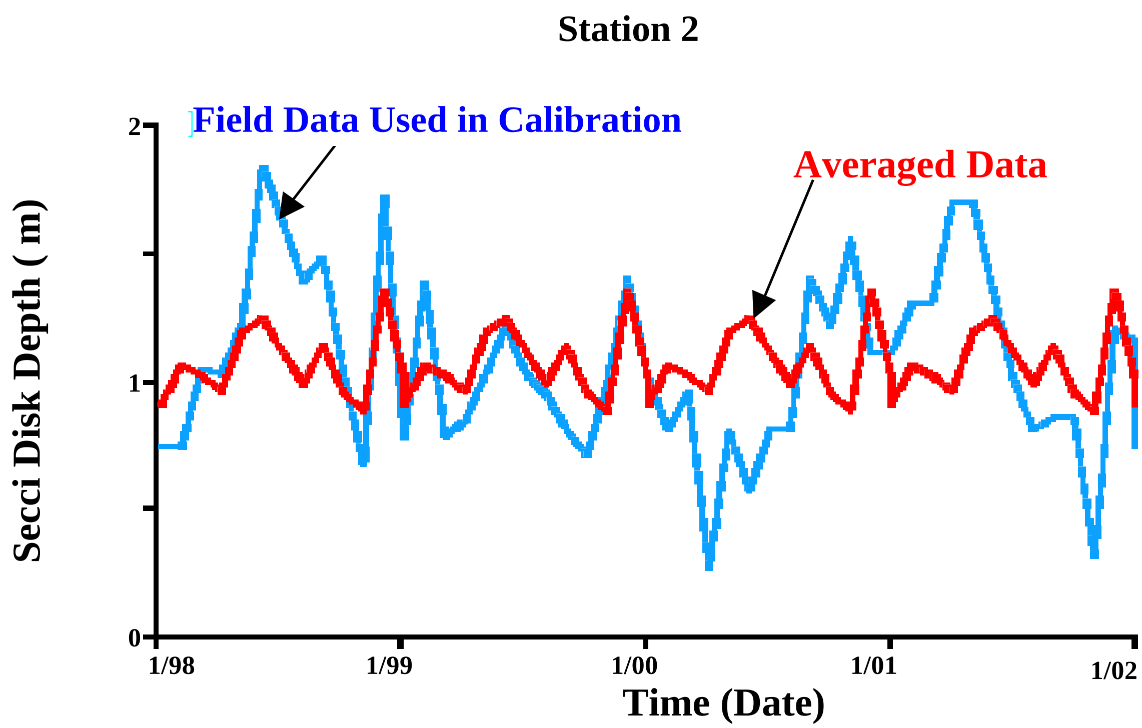
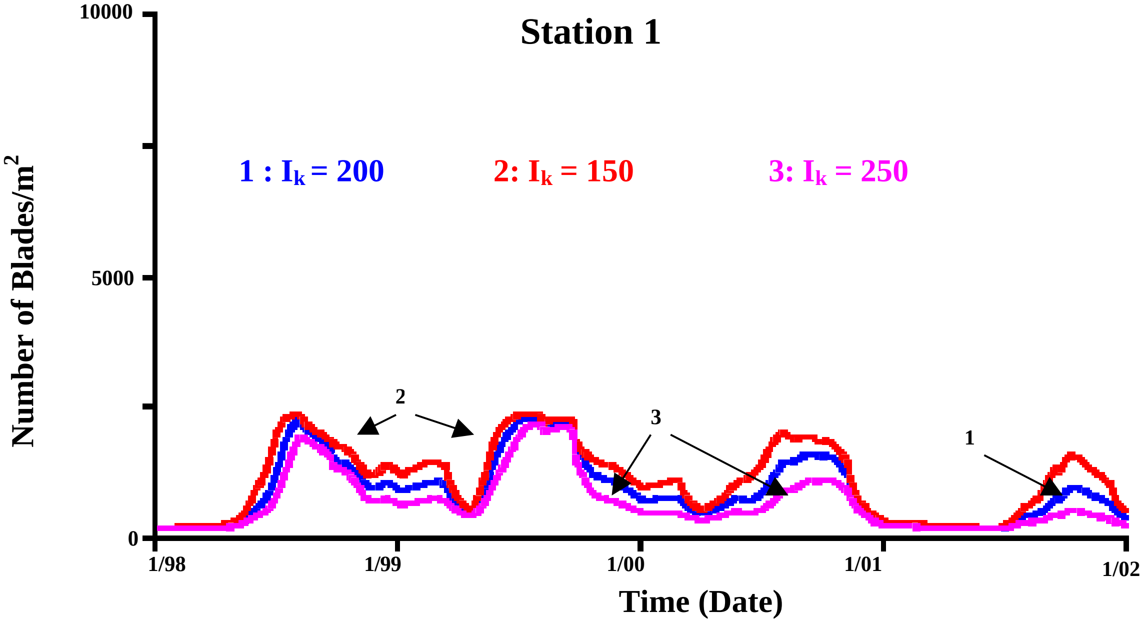


Figure H-11: Comparison of Water Transparency Input Data.



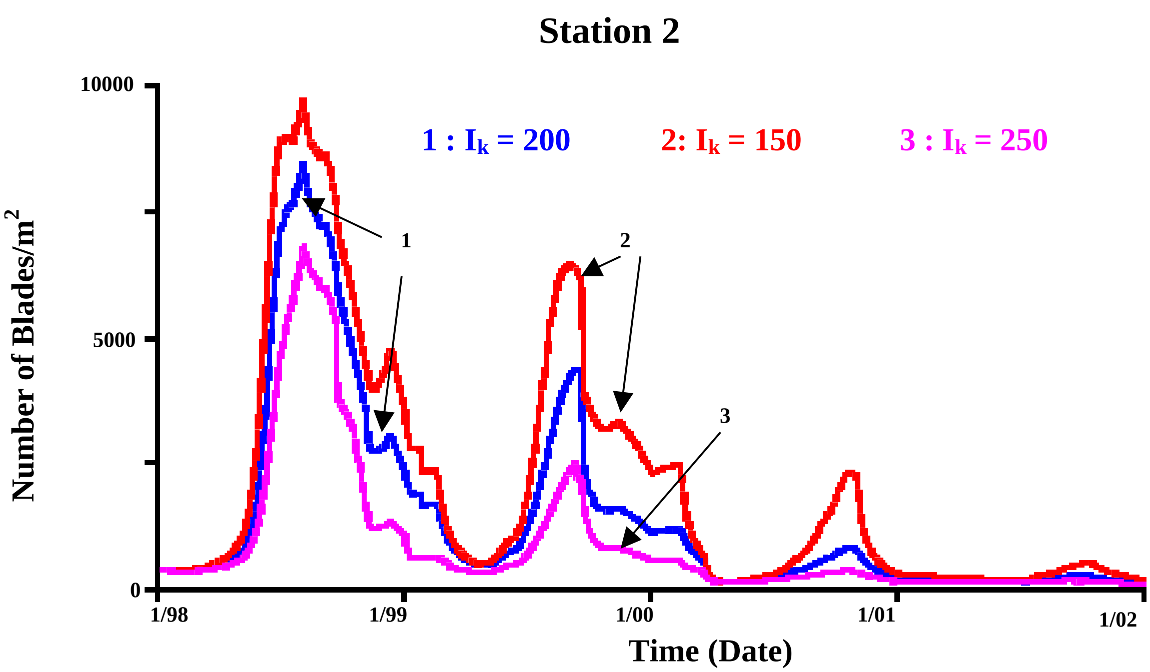


Figure H-12: Light Saturation Parameter (I_k) Sensitivity for Blade Density.

al. 2002) is expected to produce refinements in the way the P/I curve is formulated: both in terms of differences in respiration and photosynthesis under high and low salinity as well as prior light exposure/acclimation.

Temperature

Comparison of averaged temperature input file and the field data does not show a significant impact on the computed *V. americana* densities for either Station 1 or Station 2 during the four-year calibration period (**Figures H-13** and **H- 14**). In addition, raising optimal growth temperature to 36 ^{o}C, reducing maximum growth temperature to 45 ^{o}C or changing the Q10 values did not have significant impacts (data not shown).

31-Year Scenarios

To evaluate plans for watershed management, *V. americana* computations for Station 1 and Station 2 were generated under the following two scenarios:

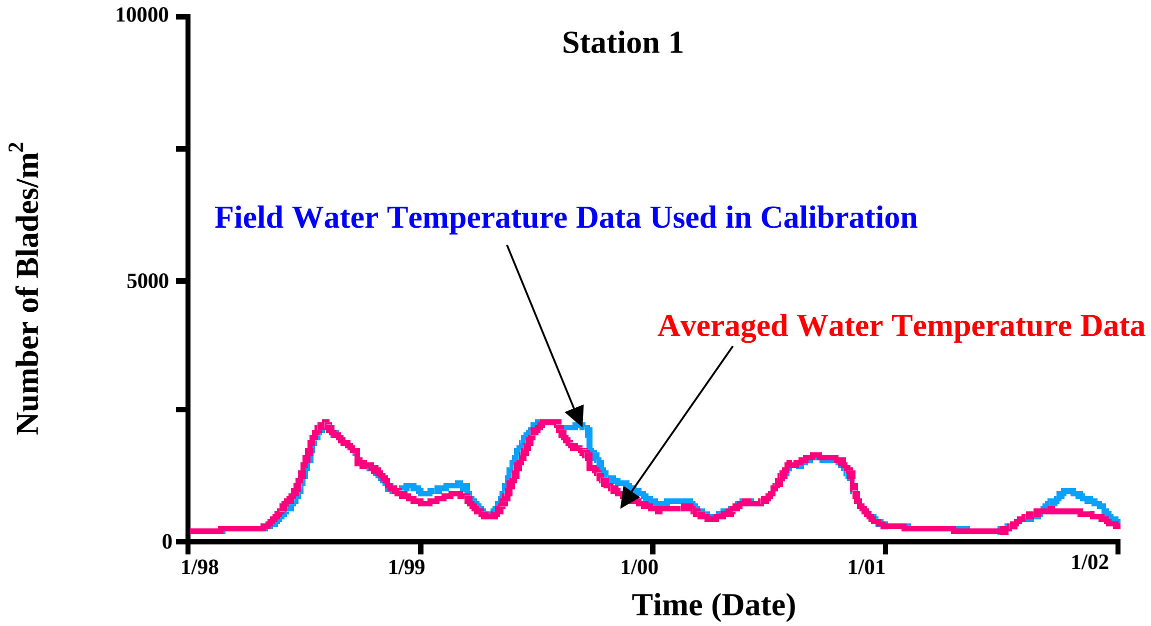
- 31-year period simulation using 1995 Base Case condition flows,
- 31-year period using CERP D13R project condition flows.

Data Needs

The input data is summarized in **Table H-3.** In both simulations, daily salinity predicted by a regression equation derived from a 3-D hydrodynamic model (**Appendix F**), served as input to the *V. americana* model. Input water temperature, secci disk depth, and PAR were determined using averaged annual data sets (determined from the calibration period). Therefore salinity was the only dynamic variable in these simulations and the remaining inputs were maintained as "average conditions" throughout each annual cycle.

Table H-3. Input Data Summary For 31-Year Scenarios

INPUT DATA	SOURCE (FREQUENCY)
Salinity (ppt)	Regression model based on hydrodynamic model (daily avg.) see **Appendix F** this document
Water Transparency (m)	Averaged data set used for calibration from 1998-2001 (monthly)
Incident PAR ($\mu E/s*m^2$)	Averaged data set used for calibration from 1998-2001 (average daily)
Water Temperature (^{o}C)	Averaged data set used for calibration from 1998-2001 (monthly)



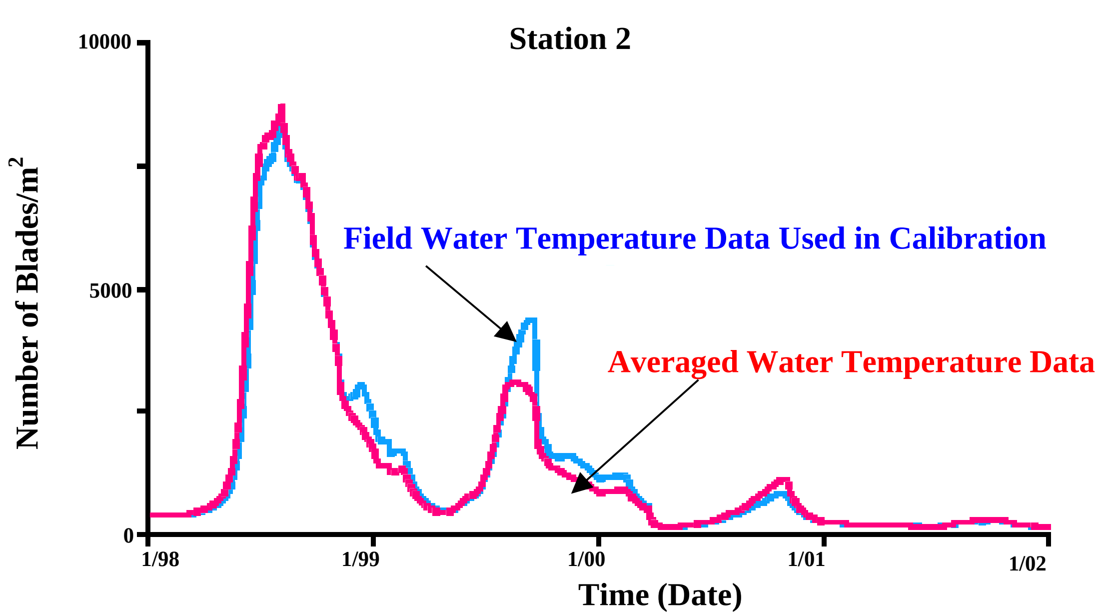
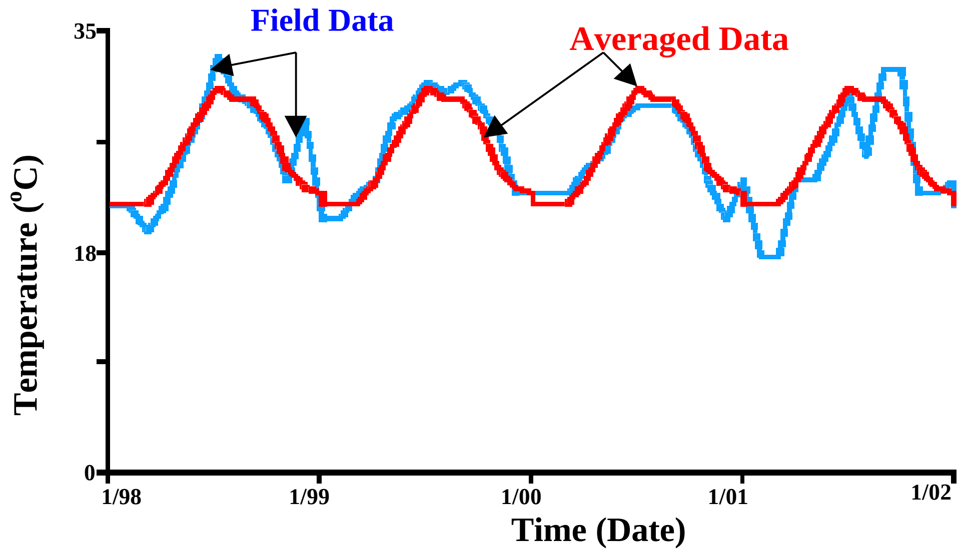


Figure H-13: Results of Modeled *V. americana* Blade Densities Using Different m Water Temperature Input

Station 1



Station 2

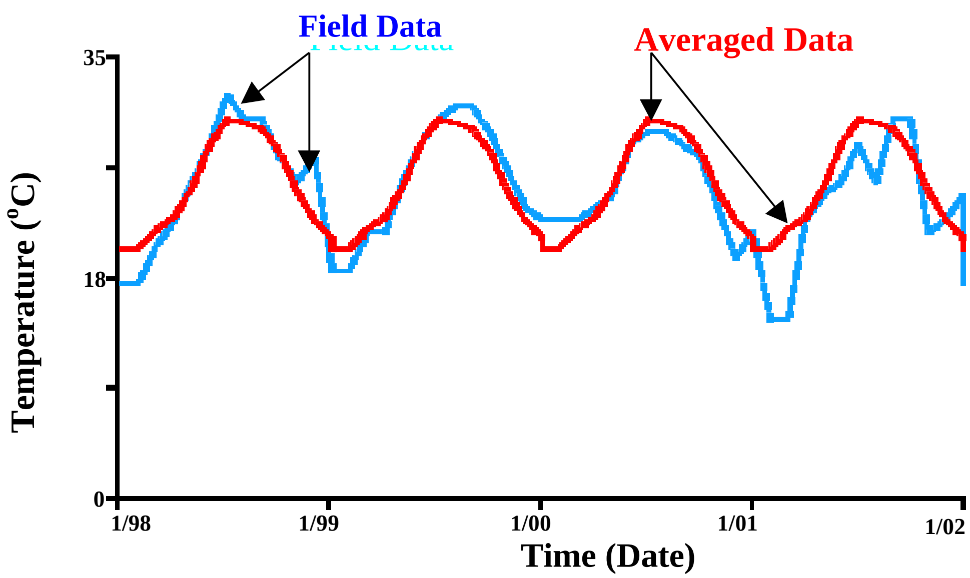


Figure H-14: Comparison of Water Temperature Input Data

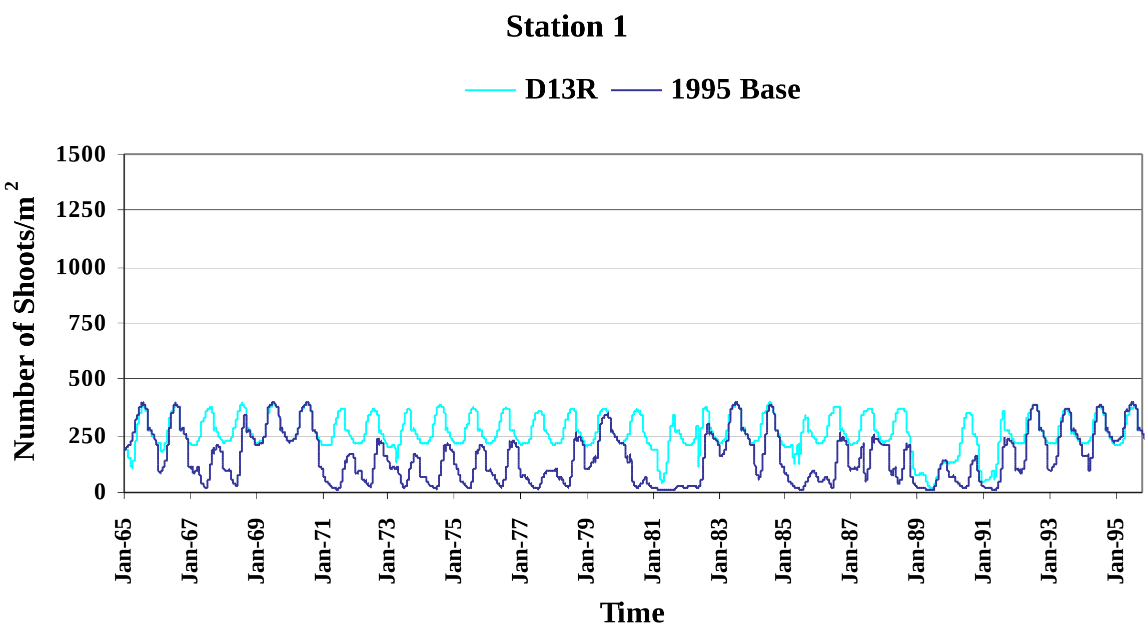
The simulations using the CERP D13R project flow conditions show more favorable *V. americana* densities than the 95 base case at both Station 1 and Station 2 **(Figures H-15** and **H-16).** Specifically, there is a 68% increase in total number of shoots produced for the 31 year period modeled at Station 1 and 51 % increase at Station 2 in the D13R scenario compared to the 95 base case. For blade density, there is a 74% increase at Station 1 and 23% at Station 2 in the D13R scenario compared to the 95 base case.

Assumptions and Limitations

In addition to the general model limitation and assumptions stated previously there are further considerations when evaluting the outcome of the 31-year scenarios.

1. Due to the fluctuation of salinity within small timesteps, daily input is preferred. In order to accommodate this scale, salinity input to the *V. americana* model was provided using a regression equation model derived from a 3-D Hydrodynamic model **(Appendix F)**. Thus the model is calibrated using salinity data that is predicted from a model and carries with it the errors associated with this input data.

2. The model also requires direct input data for water temperature, incident PAR and water transparency. Field measurements of these variables are directly input in the four-year calibration runs. In the 31 scenarios, these three variables are estimated based on yearly averages from the 4-year calibration data and are assumed to be constant from year to year. Thus, there are no light-limiting conditions or temperature extremes represented in the 31-year scenarios. As illustrated in the sensitivity analysis, use of the averaged annual input files can result in differences in computed *V. americana* density than those using dynamic field data **(Figures H-10 and H-11).** Specifically, a notable limitation of the 31-year simulations is that these simulations do not represent deviations in transparency that may occur in the upper portions of the Estuary. Such deviations that would be expected to negatively impact growth may occur due to algal blooms, highly colored discharges or sediment transport. Specifically the scenario, which is occurs in the third year of calibration (2000) is not represented by the 31-year scenarios shown (**Figures H-4 to H7)**. Similarly, periods of high water clarity such as are represented in



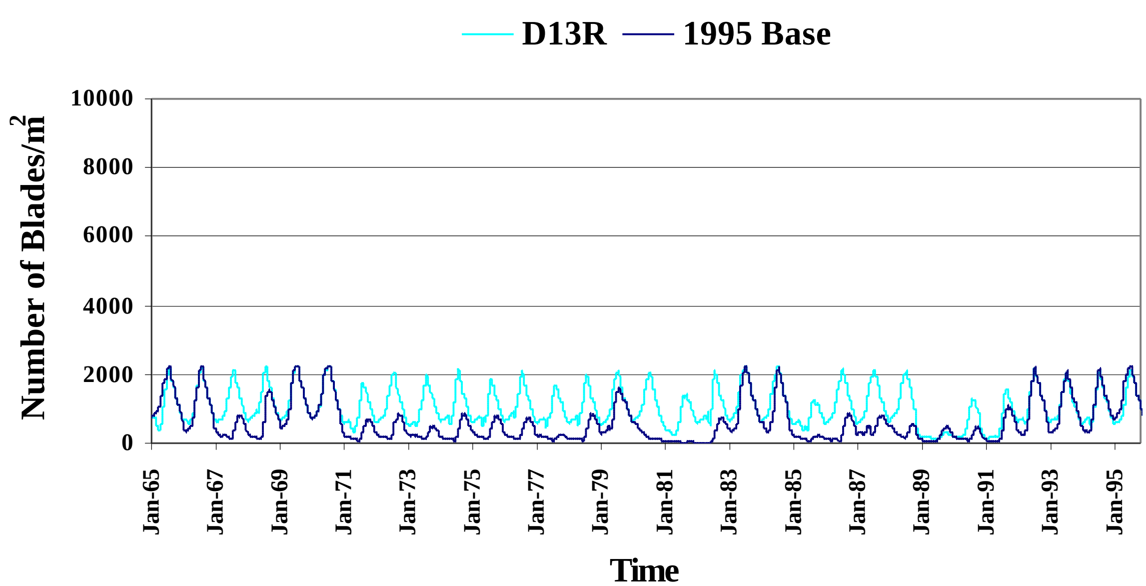


Figure H-15: Results of 31-Year Scenarios - Shoot Density

Station 2

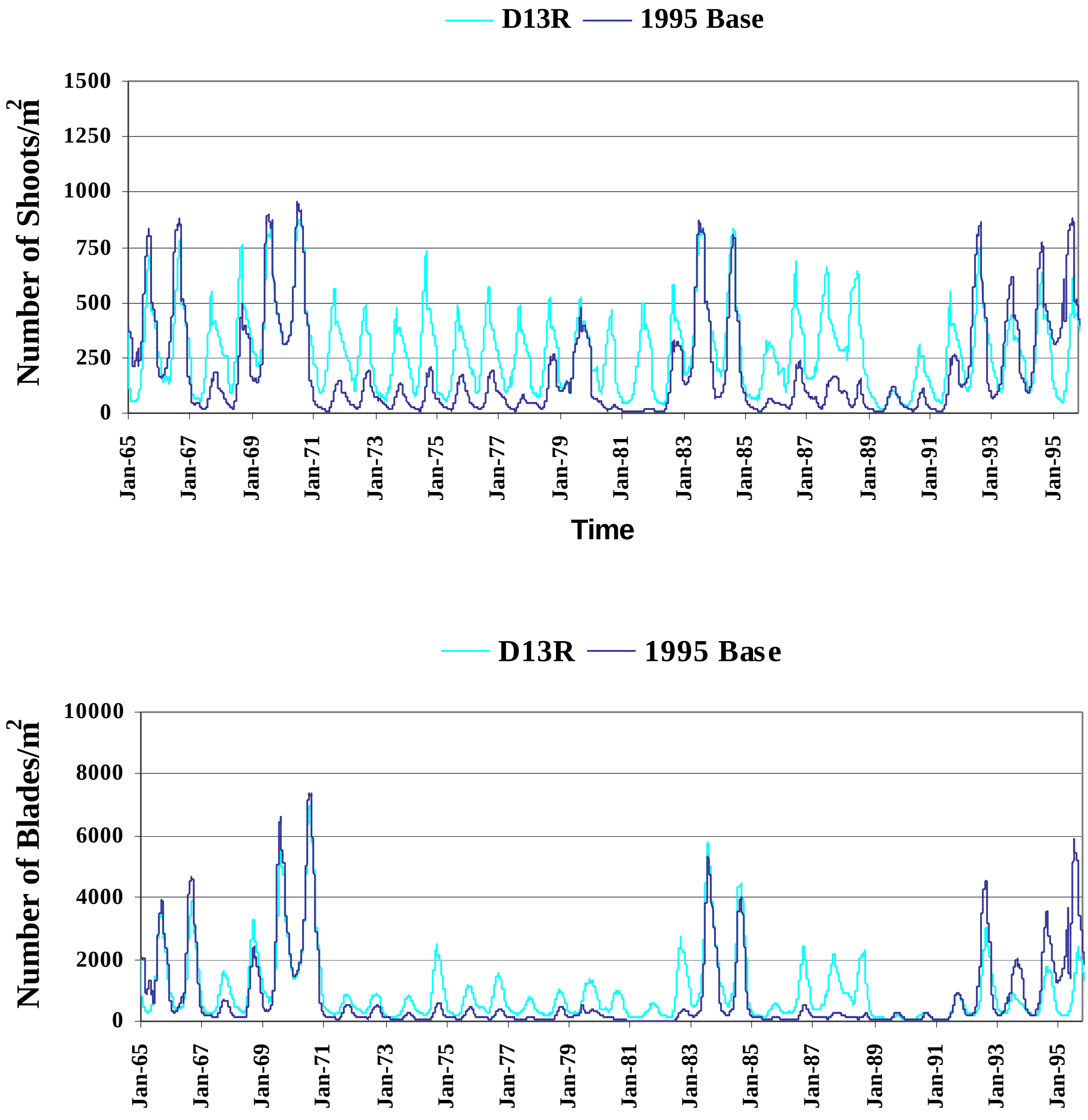


Figure H-16: Results of 31-Year Scenarios - Blade Density

the calibration period during the summer of 1998 may produce exceptional growth conditions and is not represented in the 31-year simulations.

3. The water depth at each site is assumed to be constant over the 31-year period.

Future Improvements

Due to the limited amount of time available to construct and calibrate the *V. americana* model, improvements are anticipated. It is necessary that all field monitoring be continued and the calibration period be extended to include the new data. The extended calibration period will permit improved prediction of *V. americana* recovery after severe conditions. Additional input data and information concerning the growth and survival of *V. americana* in the Caloosahatchee Estuary will be required to make the model more robust. Information is needed for validation of some existing equations, refinements to salinity, light and temperature effects as well as development of additional state variables. Equations representing additional important ecosystem components will be incorporated into the model. Potential examples include: sediment characteristics, current, sediment diagensis, biogeochemical rate processes, sulfide, flowering, and competition for light and nutrients by plankton and microphytobenthos. The relative importance of these variables and the information needed to quantify these effects are currently under review. Additional forcing functions may be added such as color, chlorophyll-a, suspended solids, and nutrients. State variables describing additional plant morphologies such as canopy height, and below ground biomass may also be added. Future work, outlined below, falls into three broad categories, data analysis, model development, and experimental or site work.

Data analysis

- Develop a method to predict variation in water transparency for long-term or other simulations.

- Quantify input data error and perform additional sensitivity analysis.

- Develop relationships to relate mass to blade and shoot densities, and blade length with existing data.

Model Development

- Quantify existing experimental work (Hunt et al., 2002) and develop improved algorithms for light and salinity.

- Incorporate blade length as a state variable to more accurately represent light availability for mature plants.

- Add nutrient cycling/ water quality impacts.

- Add population and demographic characteristics to describe seed production and dispersal.

Experimental /Site Work

- General areas of data needs include: above and below ground biomass measurements at existing sampling stations, levels and influence of pore water salinity and sulfide, and direct light attenuation measurements. Field measurements should be obtained under differing environmental conditions.

- Identify the factor(s) responsible for reduced carrying capacity in Station 1 relative to Station 2. Some factor(s) other than light attenuation (as measured by secci disk), salinity or temperature governed the growth of *V. americana* at Stations 1 during the four-year calibration period.

- Develop criteria and cues (including lag times) for reestablishment of *V. americana* growth after population has been substantially reduced. The assumption that reestablishment occurs via a seedbank should be verified.

CONCLUSIONS

The ecological model described, although still in the developmental stages, synthesizes known information about the growth and survival of *V. americana* in the Upper Caloosahatchee Estuary. Calibration of the 4- year period 1998-2001 indicates reasonable agreement with field data. It is expected that improvements will be forthcoming as the model is further developed.

The four primary criticisms (listed previously) of the peer reviewers for the Draft MFL Document of September 2000 (SFWMD, 2000) are being addressed by the development of the ecological model. This model includes the effects of multiple environmental variables: salinity, light, and temperature. Additional variables such as nutrient cycling and sediment diagenesis will be added to the model as appropriate. The issue of spatial variability is addressed by verifying and calibrating the model at two locations within the Upper Caloosahatchee Estuary. Additional locations further downstream may be added in the future. In terms of demographic variability, the model predicts several measures of growth including shoot density, blade density and, biomass. The capability to predict average canopy height will also be included in the future. Long-term (31-year) simulations with variable input salinity regimes derived from a hydrodynamic model are presented addressing another criticism. Finally the panels concern regarding the annual shoot recovery densities set as constant has also been addressed. The current model allows for the user to either input any desired starting density or calculate a density given a previous years growth by performing multiple-year simulations.

The model can be used as a tool to assess management strategies in the Upper Caloosahatchee Estuary. Information generated by the model can eventually be used to optimize timing and quantity of freshwater releases to the upper estuary as indicated by MFL criteria. The model can also be used to identify important factors influencing *V. americana* growth and survival. Simulations can be used to test hypothesis concerning the influence of freshwater flows on *V. americana* productivity and survival. Mechanisms responsible for habitat decline can be elucidated and conditions required for restoration and survival can be evaluated. A set of habitat requirements for *V. americana* survival and growth for target densities can be then established at different locations within the Upper Caloosahatchee Estuary. Compilation of existing data and sensitivity analysis within the model framework can highlight areas of data needs and be used guide and prioritize future work efforts.

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